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REVIEW OF EFFLUENT POLISHING

PILOT PLANT STUDY

BRAMPTON - CHINGUACOUSY WPCP

THE ONTARIO WATER RESOURCES COMMISSION

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REVIEW OF EFFLUENT POLISHING

PILOT PLANT STUDY

BRAMPTON - CHINGUACOUSY WPCP

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SUMMARY

The Division of Research of the Ontario Water Resources Commission has completed a pilot plant study of an effluent polishing process employing an aeration pond followed by a conventional lagoon.

Several conclusions concerning the use of an aeration pond as an effluent polishing facility have been reached:

1 - A minimum allowable loading, determined by the nutrient composition of the influent, and a maximum allowable loading set by the capacity of the aeration system will be experienced. In the case of the OWRC research project the limits were 0.9 and 5.0 lb BOD/1000 cu ft/day, respectively.

2 - Temperature variations between 24° and 6°C have little effect on treatment. Treatment is decidedly reduced at temperatures below 5°C.

3 - Retention periods of 1 to 2 days achieve a relatively constant BOD reduction. Employing either mechanical or chemical suppression of algae, longer retention periods would increase treatment efficiency.

4 - Unless provision is made for either preventing excessive settling of sludge, or for sludge removal, difficulties in treatment will be experienced during the warm-up period of the spring season.

5 - Dissolved oxygen levels should not be allowed to drop below 1.5 ppm at any time.

6 - An effluent of between 4 and 8 ppm BOD should be achieved if the influent BOD concentration does not exceed 15 ppm.

Continued.....

The results of this study show that tertiary treatment is not a substitute for reliable secondary treatment. Under proper operating conditions and adequate aeration, an influent BOD of 15 ppm should be reduced to below 8 ppm in a tertiary aeration pond. This aeration pond should then be followed by a conventional lagoon to allow sludge settling and to raise the dissolved oxygen content of the waste to at least 4 ppm before it is introduced to the receiving stream.

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INTRODUCTION

The information contained in this report presents a review of the results of the effluent polishing pilot plant study at the Brampton WPCP as performed in the period August, 1964 to July, 1965. This report deals only with the aeration pond as it received supplementary aeration by an Aero-Hydraulics aeration system and the conventional lagoon coupled in series with the pond.

At the time of this study, the WPCP was heavily overloaded and thus, the pilot plant was subjected to great variation in loading and influent concentrations as well as retention time and environmental conditions.

The report is separated into Part I, dealing with the aeration pond and Part II, dealing with the lagoon as tertiary treatment facilities.

TREATMENT REQUIREMENTS:

In view of the low dilution available in Etobicoke Creek, the polishing treatment should ensure a consistently good effluent with respect to 5-day Biochemical Oxygen Demand (BOD), dissolved oxygen (DO) and settleable solids (SS). Such an effluent should not develop septic conditions downstream from the plant.

An accurate prediction of conditions that would prevail in Etobicoke Creek below a full effluent polishing plant can not be determined from the data collected because of the masking effect of the effluent from the old plant upstream, and the presence of effluent, not receiving polishing treatment, downstream from the Brampton Plant.

It would appear however, that if the effluent leaving the polishing facility had a maximum BOD of 8 parts per million (ppm) a SS concentration of less than 15 ppm and a DO content of 4 ppm, no difficulties due to this effluent should be experienced in the receiving stream.

PART I

Part I of this report deals with the aeration pond as an effluent polishing facility to relieve the BOD and solids load that the Brampton WPCP imposes upon Etobicoke Creek.

PILOT PLANT UNIT

The aeration pond was constructed in 1964 with its operation and studies commencing in August of that year. It is an earth-dyke basin with side slopes of approximately 2:1, a depth of 14 ft. and a volume of 420,000 Imperial gallons. Average flow during the study was 250,000 gallons per day (gpd) ranging from 453,000 to 877,000 gpd.

Aeration was provided by an Aero-Hydraulics aeration system consisting of four Aero-Hydraulics aeration guns, model #2. From data presented by the Aero-Hydraulics Corp. the value of tap water oxygenation capacity at zero DO of the model #2 gun is 1.46 lb/hr. Allowing a reduction of 20% for the effect of surface active agents, an oxygenation capacity of 1.16 lb/hr. is predicted at zero DO concentration in the waste water.

The four guns, as placed in the aeration pond, provided mixing which was adequate to maintain a relatively uniform dissolved oxygen value in the entire pond contents but was not adequate to maintain all settleable solids in suspension.

AERATION POND TREATMENT PROCESS

Although the aerated lagoon is theoretically a "total oxidation" system in that the endogenous activity of the organisms is sufficient to destroy the cells created each day, some buildup in sludge will generally occur. The amount of sludge buildup is a function of the turbulence created by the aeration equipment and the hydraulic design. In the case of the Brampton pilot plant the Aero-Hydraulics guns created considerably less turbulence than that generally experienced with mechanical aeration units. It was estimated that 40% of the sludge settled to the bottom of the basin. The system was then, a mixed aerobic-anaerobic system.

In such a system, the heavier suspended solids, including biologically formed floc, is allowed to settle to the bottom of the basin where those matters subject to anaerobic decomposition are free to do so. The liquid and gaseous products of decomposition released at the sludge-water interface are carried by the circulating mixture into the aerobic zone above and utilized by the aerobic organisms, preventing the release of obnoxious gases to the atmosphere.

During cold weather, anaerobic activity slows down considerably more than aerobic activity with a resulting bottom storage of BOD at low temperatures. As temperatures begin to rise in the spring, anaerobic activity increases and the system is then subjected to an added load. A slight odour problem may arise with an accompanying decrease in apparent BOD removal.

At the Brampton pilot plant this pheonomenon occured in late May and early June of 1965 with an extended period of negative apparent BOD removal efficiency.

INTERPRETATION OF RESULTS

In order to reduce the large accumulation of data to useable proportions, all determinations have been based on weekly averages of test results. The test period covered in this report consists of 52 weeks of data collecting. Because of the incompleteness of data for several of the weeks, however, the results and data obtained from 35 of the weeks of operation have been used as a basic for the conclusions of this report.

Whenever possible, mass balance values rather than actual concentration have been used. In this manner, changes in concentration within the aeration pond are accounted for.

Because of the numerous variables encountered during the study a detailed analysis has been made in an effort to

separate the influence of each factor, and to establish a direct correlation between each of these variables and effluent BOD concentration. Allowable limits of some of these variables have been set.

RESULTS

A - Biochemical Oxygen Demand (BOD)

The variables affecting effluent BOD concentration considered in this report are BOD loading, influent BOD concentration, retention period, temperature, settling, algae concentration and oxygen utilization. Weekly averages are presented in Table 1.

A description of the effects of each of the above variables on BOD effluent concentration and reduction is presented below:

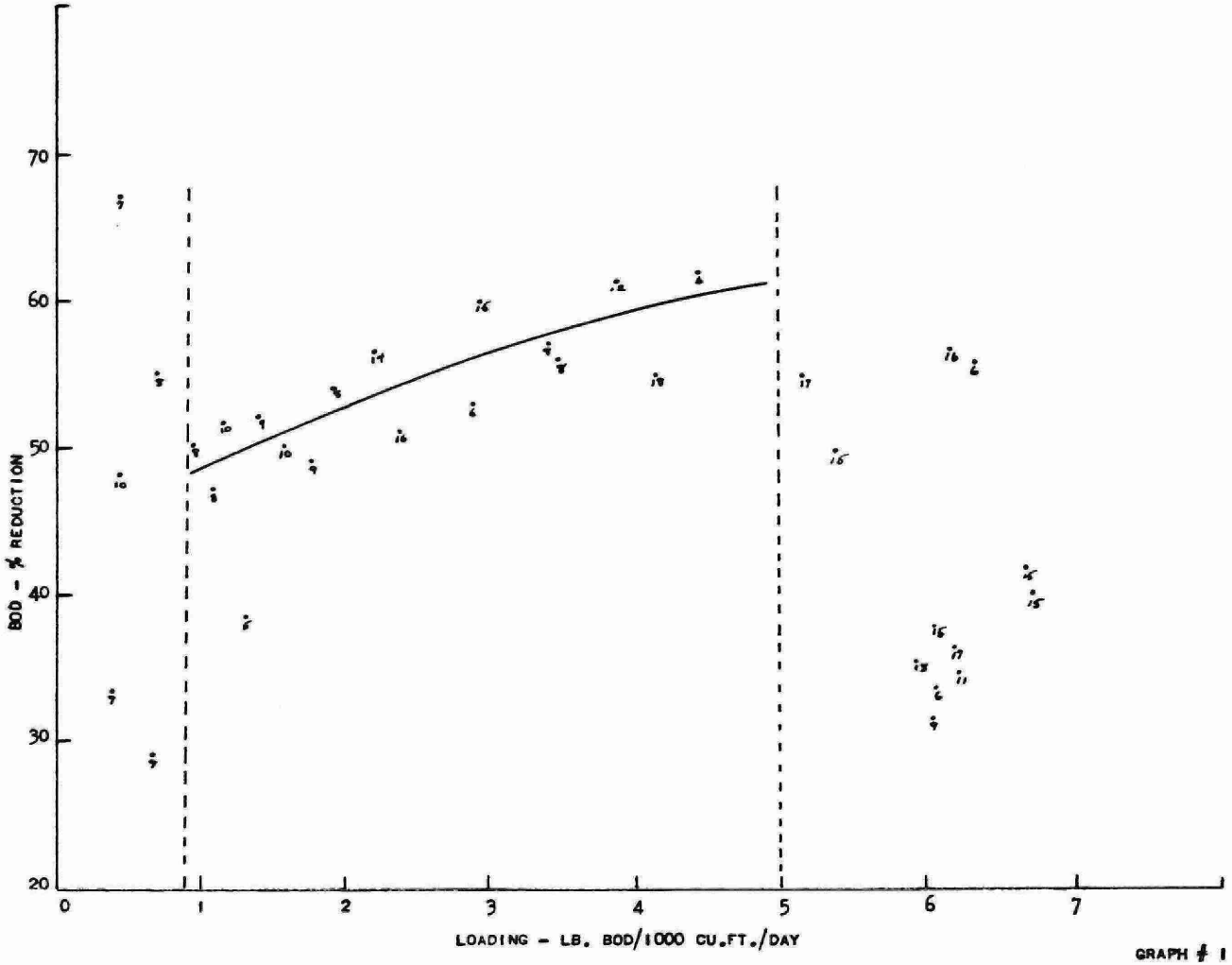
1) Loading - A plot of loading vs BOD percent reduction is presented in Graph #1. This graph indicates that between the loadings of 0.9 and 5.0 lb BOD/1,000 cu ft/day, a fairly predictable BOD reduction was achieved for the period August, 1964 to May, 1965. As has been outlined, unpredictable results, because of bottom deposit effects, occured during May and early June.

Below a loading of 0.9 lb BOD/1,000 cu ft/day, BOD reductions were highly variable ranging between 29 and 67%. This was partly due to the inert nature and composition of the waste at low loadings and partly due to the resulting long retention periods and high algae concentration at temperatures above 14°C.

At loadings above 5.0 lb BOD/1000 cu ft/day, oxygen became limiting and again BOD reductions were unpredictable and somewhat reduced.

Week No.	Loading (#BOD/ 1000 cuft/ Day	Ret. Time (days)	BOD Red (%)	Infl. BOD (ppm)	Effl. BOD (ppm)	Temp. (°C)	DO (ppm)	a (#DO/ #BOD_r)
10	6.12	0.9	57	60	26	16	2.1	0.52
11	5.35	1.0	50	56	28	15	3.0	0.58
12	6.65	0.9	42	62	35	15	1.6	0.71
13	3.98	1.1	51	45	24	14	3.2	0.94
14	3.40	1.4	50	51	25	15	3.4	1.75
15	2.90	2.0	60	62	25	15	1.2	2.82
16	1.67	2.2	65	38	16	13	3.8	3.25
17	1.55	2.2	50	35	17	10	5.6	3.49
18	1.76	2.2	49	41	20	9	4.4	2.12
19	1.05	3.7	47	41	31	8	8.2	5.96
20	0.91	3.9	50	37	17	8	0.7	5.72
25	4.40	2.0	62	65	31	6	7.5	0.91
26	6.30	1.2	56	67	33	6	2.3	0.70
27	3.86	1.3	45	48	28	5	4.6	1.11
28	3.36	1.2	57	41	19	8	7.2	0.51
30	2.86	1.1	53	32	15	6	7.8	0.89
31	3.42	1.3	56	44	19	8	7.6	0.80
32	1.38	1.3	52	17	10	7	8.4	1.44
33	1.88	1.2	54	24	11	8	8.7	0.58
34	1.67	1.2	38	21	13	7	7.8	0.60
35	0.43	4.6	67	21	10	7	10.3	0.34
36	0.69	4.2	55	30	12	8	10.1	0.30
37	0.66	4.0	29	28	17	9	9.3	0.85
38	0.38	4.2	33	16	13	9	9.1	2.06
39	0.42	4.0	48	16	13	10	8.5	1.22

Table 1 - Aeration Pond
Brampton Pilot Plant
Average Weekly Results - Sept., 1964 to May, 1965



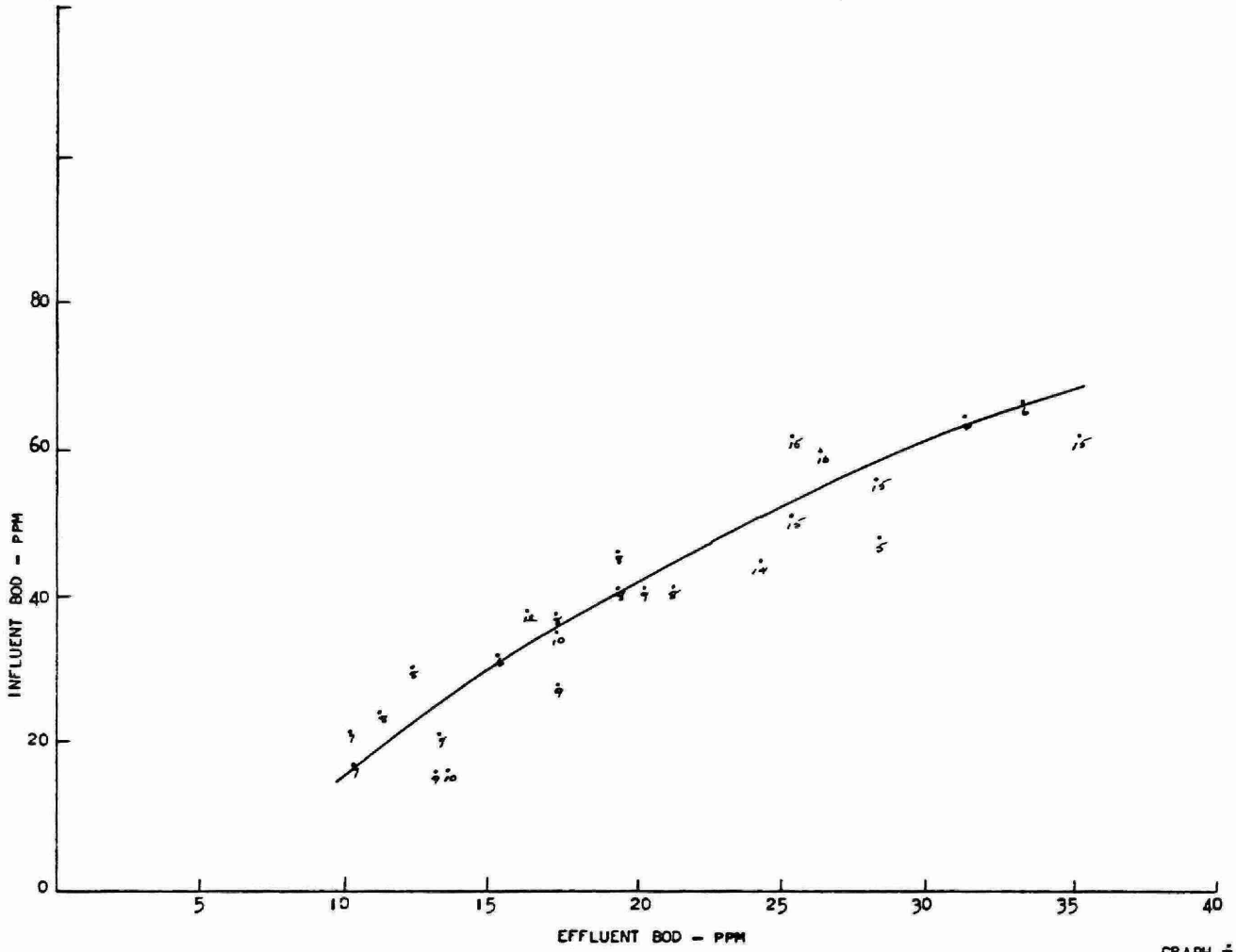
GRAPH # 1 APRIL 1966

BOD % REMOVAL/LOADING

AVERAGE WEEKLY RESULTS - OCT./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP.(°C) GIVEN FOR EACH POINT



GRAPH # 2 APRIL 1966

EFFLUENT BOD/INFLUENT BOD

AVERAGE WEEKLY RESULTS - OCT./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (^{o}C) GIVEN FOR EACH POINT

2) Influent BOD Concentrations - A plot of influent BOD vs. effluent BOD is presented in graph #2. As can be seen, a fairly direct relationship between effluent and influent has occured over the entire range of influent concentrations experienced between the months of August and May.

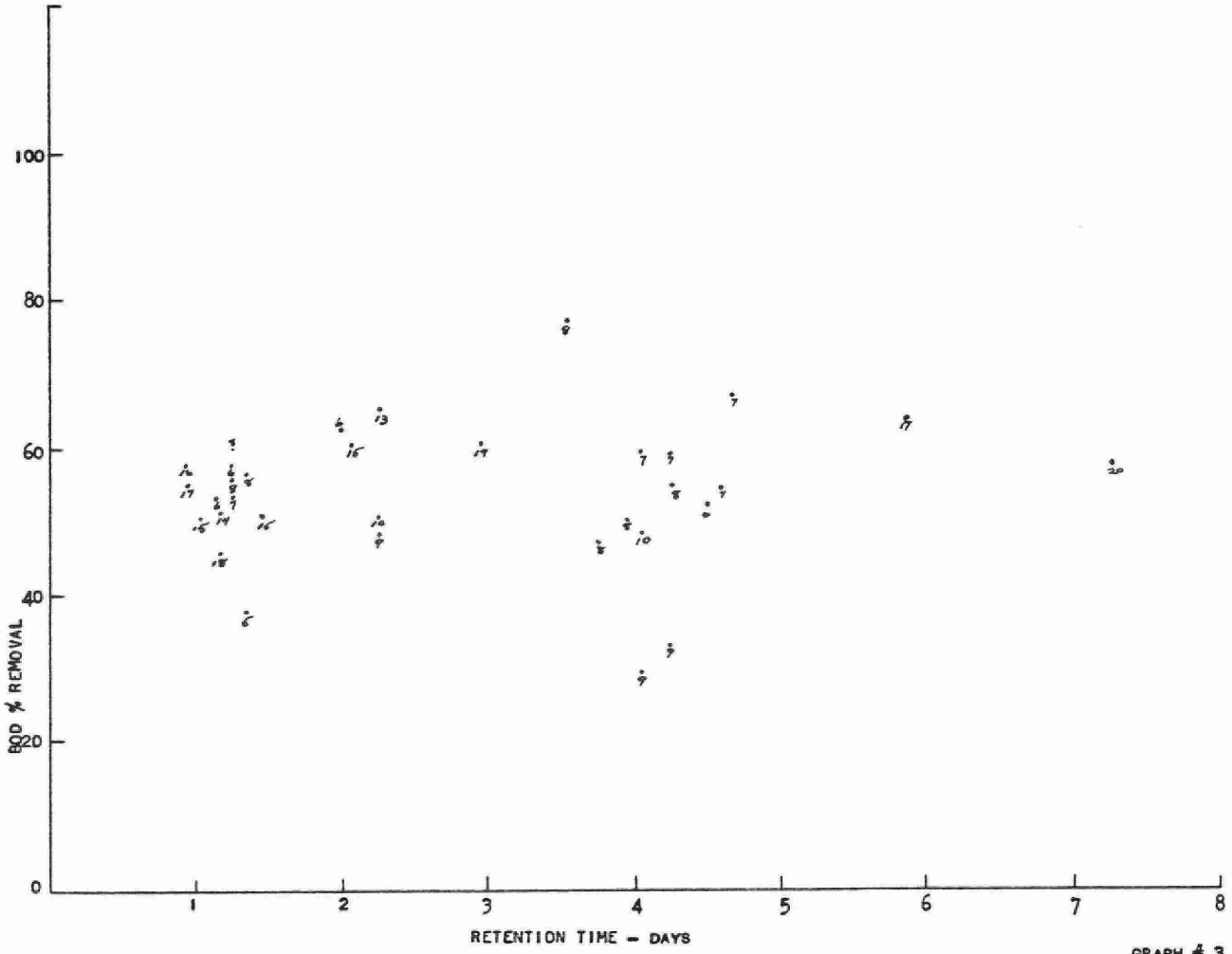
For a polishing process treating waste from a properly designed and operating secondary plant, the influent to the process should seldom exceed a maximum concentration of 15 ppm BOD. From the results of these studies it would appear that at these low influent concentrations reductions will be in the order of 40 to 55%.

3) Retention Period - Even though no direct relationship could be established between per cent BOD reduction and retention period, as seen by graph #3, it would appear that retention periods between 1 and 3 days did produce the most predictable reductions. Between these limits BOD removal varied between 45 and 80%.

Longer retention periods were generally coincidental with low organic loadings, and shorter retention periods with high loadings.

There appeared to be a tendency towards an increase in treatment efficiency as retention period increased from 1 to 3 days.

4) Temperature - As the temperature of the mixed liquor decreased from 20°C in August to 6°C in February and then rose to 10°C in late April, it appeared to have no direct effect upon treatment efficiency and the operation of the aeration pond except at one point where temperatures dropped below 6°C. (Temperatures have been indicated with each point in graphs 1 and 2). However, as temperatures increased from 10°C to 15°C through May and June, the efficiency appeared to drop off radically. This phenomenon has previously been explained.



GRAPH # 3 APRIL 1966

BOD % REMOVAL/RETENTION TIME

AVERAGE WEEKLY RESULTS - OCT.64/-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (^{o}C) GIVEN FOR EACH POINT

At high temperatures and long retention periods, dense concentrations of algae were found, reducing BOD removal efficiency.

5) Settling - It has been estimated that approximately 40% of the BOD load settled out in the aeration pond, and became available for utilization by the aerobic organisms only at rates dependent upon conditions affecting an aerobic decomposition.

The effect of settling on the performance of the anaerobic pond may be observed from the wide variations in BOD removal throughout the period May to July.

Measurements and samples of settled materials were not regularly taken throughout the entire study period, but sampling in May of 1965 revealed heavy deposits of settled sludge.

6) Algae Concentrations - Algae concentrations are dependent upon many factors including nutrient conditions, light intensity and duration, retention time, degree of turbulence and turbidity and temperature.

Table 2 presents weekly averages of algae concentrations and of some of the factors affecting these concentrations. These factors cannot, however, be isolated to determine limits for each as there was no means of keeping any one factor constant for any period of time. Generalizations, however, may be drawn:

a) temperatures below 10°C inhibited high concentration of algae, (See Graph #4).

b) a combination of retention periods in excess of 1.5 days, temperatures in excess of 14°C and radiation in excess of 150 gram-calories per square centimeter provided the proper conditions for excessive algae growth.

c) extensive algal growth has a detrimental effect on BOD reduction.

d) there appeared to be adequate nutrients available at all time to support large populations of algae.

7) Oxygen Utilization - Calculations were made using weekly averages, to determine the oxygen required in relation to the BOD removed. These values are shown as (a) in Table 1 and ranged from 0.3 to 5.9 lb DO/lb BOD removed. An overall figure for the entire study period, assuming a transfer of 1.6 lb 02/unit/day at zero DO and a benthal oxygen demand of 1.0×10^{-3} lb/ft^2/day(1)(3) was calculated to be approximately 0.78 lb DO/lb BOD removed.

Some factors affecting oxygen utilization are the applied load, temperature, settling, waste characteristics and PH. Variations in all of these would account for the radical change in the value of (a) from week to week.

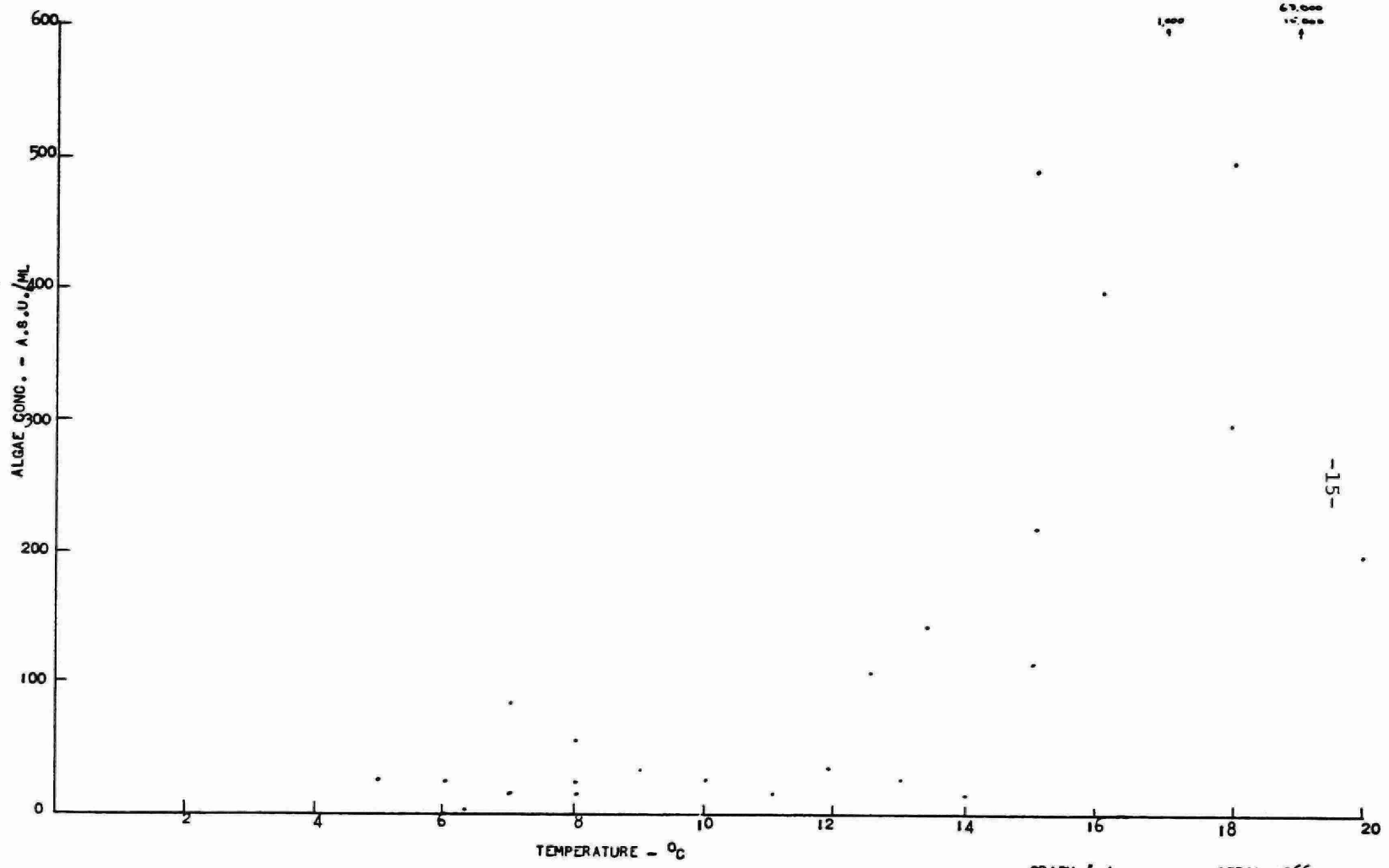
B - Suspended Solids

Table 2 presents the weekly average values of influent SS, effluent SS and % reduction. Graphs #5 and #6 present plots of SS % reduction vs retention time and effluent SS vs algae concentrations.

No correlation could be established between retention time and SS% reduction. However, as would be expected, there appears to have been a direct relationship between algae concentration and effluent SS. Algae densities present appear to have been the main contributor to the scatter of Graph #5.

Week	Radiation gm.cal. cm^{-2}	Temp. (^{o}c)	PH (Max.)	PH (Min)	Ret. Time (days)	Algae Conc. (asu)	Infl. SS (ppm)	Effl. SS (ppm)	SS red %
2	390	19	8.2	7.9	2.9	63000			
3	382	19	8.1	7.8	2.1	15000			
4	450	17	7.9	7.8	1.6	1000			
5	447	20	7.9	7.7	1.4	500	71	32	50
6	416	20	8.0	7.8	1.7	200	56	33	40
7	435	18	7.9	7.6	1.1	300	68	42	44
8	235	18	7.8	7.6	0.9	500	62	36	40
9	230	17	7.8	7.6	0.9	275	72	41	42
10	234	16	7.8	7.4	0.9	400	66	23	77
11	284	15	7.7	7.6	1.0	492	50	20	50
12	232	15	7.7	7.6	0.9	-	45	19	64
13	206	14	7.7	7.6	1.1	15	64	21	66
14	155	15	7.7	7.6	1.4	116	60	15	76
15	118	15	7.7	7.6	2.0	220	54	31	37
16	108	13	7.7	7.7	2.2	26	102	60	43
17	105	10	7.8	7.7	2.2	26	59	26	40
18	103	9	7.8	7.7	2.2	32	80	24	78
19	118	8	7.9	7.7	3.7	54	55	20	63
20	111	8	7.9	7.8	3.9	23	66	25	63
26	--	6	7.9	7.7	1.2	6	45	20	49
27	135	5	7.9	7.8	1.3	21	45	18	60
28	180	8	7.8	7.7	1.2	15	53	18	67
30	102	6	7.9	7.8	1.1	23	38	16	53
31	183	8	7.9	7.8	1.3	23	65	23	37
32	296	7	7.9	7.4	1.2	15	53	28	43
33	256	8	7.9	7.8	1.2	-	32	17	67
34	222	7	7.9	7.8	1.2	84	32	19	37
35	260	7	8.0	7.9	4.6	12			
36	420	8	8.0	7.9	4.2	30			

Table 2 - Aeration Pond
Brampton Pilot Plant
Average Weekly Results - Aug., 1964 to April, 1965

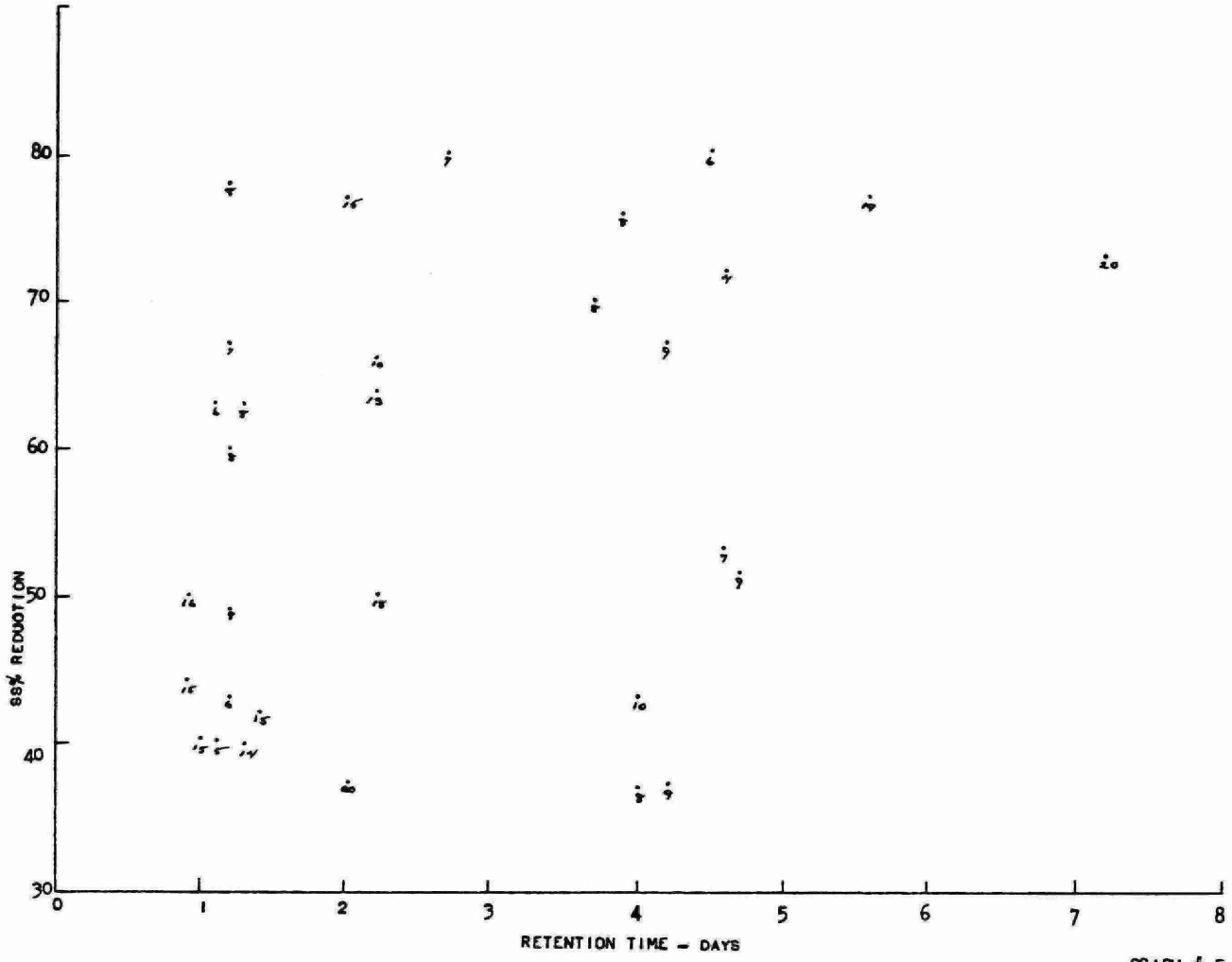


GRAPH # 4 APRIL 1966

ALGAE CONCENTRATION/TEMPERATURE

AVERAGE WEEKLY RESULTS - OCT./64-MAY/65

BRAMPTON PILOT PLANT



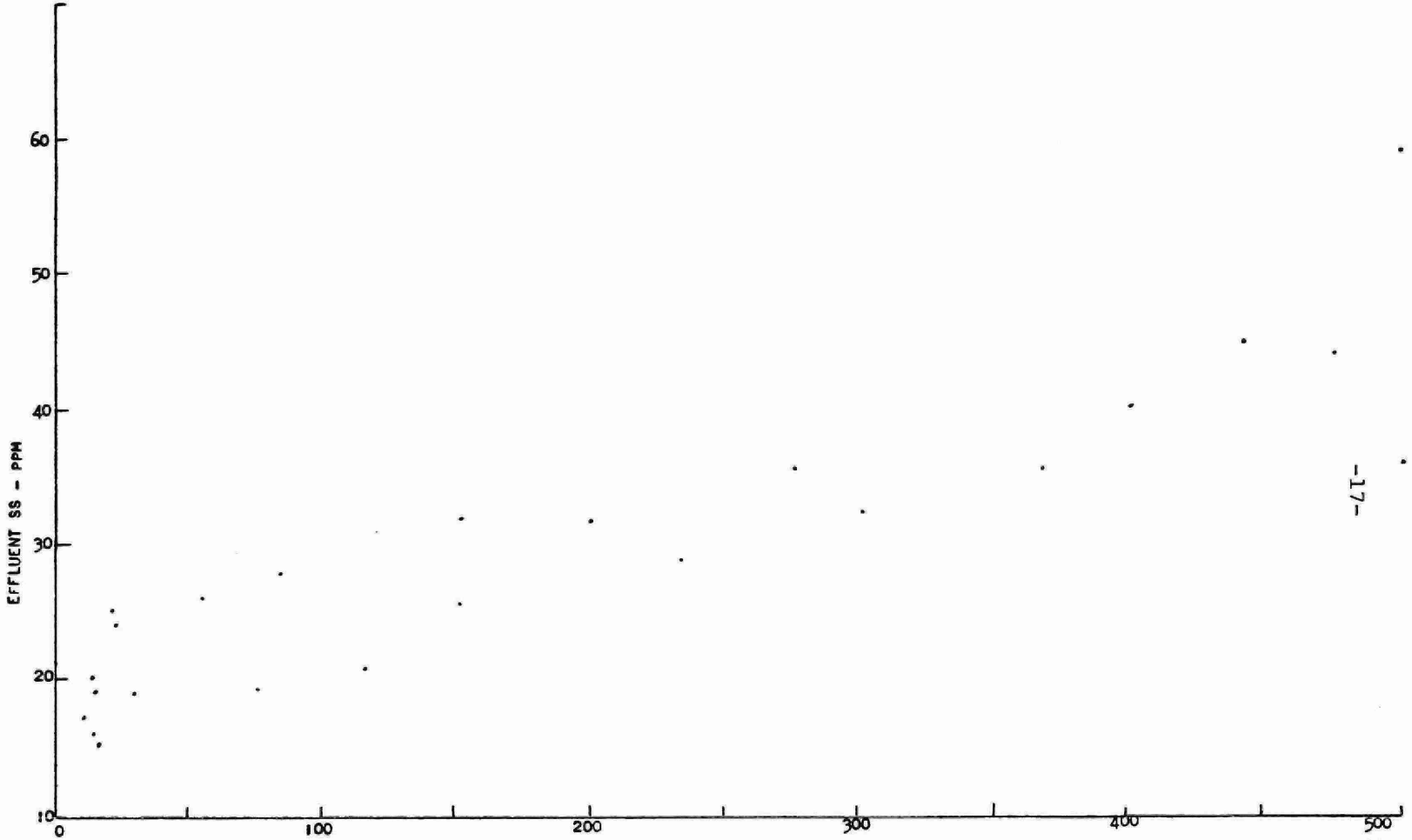
GRAPH # 5 APRIL 1966

SS % REDUCTION/RETENTION TIME

AVERAGE WEEKLY RESULTS – AUG./64–MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (^{o}C) GIVEN FOR EACH POINT



GRAPH # 6 APRIL 1966

EFFLUENT SS /ALGAE CONCENTRATION

AVERAGE WEEKLY RESULTS—AUG./64—MAY/65

BRAMPTON PILOT PLANT

Variations in temperature and influent quality were also contributing factors to a lesser extent.

There is a division of opinion concerning the effect of the algal cells in the effluent on the receiving body of water. One opinion is that certain types of algae in the effluent of ponds will continue to produce oxygen by photosynthesis in the changed environment of the receiving stream and thus, not exert the oxygen demand indicated by the BOD analysis. It is sometimes assumed that the organic matter produced by algae growth is not immediately available to produce as obnoxious a condition below the outfall as would an equivalent concentration of organic matter from sewage.

The OWRC to date has maintained a more conservative stand in not making a special allowance for suspended solids and BOD from algal origin. This concept has been adopted throughout the report for purposes of performance appraisal.

DISCUSSION

An aeration pond receiving secondary treated waste cannot be likened to an aeration pond receiving raw sewage. Raw sewage is composed of an infinite variety of substances ranging from those that are highly oxidizable to those that are completely biologically inert. In any biological treatment process, the most readily oxidizable BOD material is removed first leaving the more inert portion in the effluent. Thus the waste entering a polishing facility is much less readily treatable than that entering the conventional raw sewage aeration pond. Reductions would necessarily be expected to be somewhat lower. It would follow then, that the lower the influent BOD applied to the polishing process, the less will be the reduction effected by the process, especially at low BOD concentrations. This is evident from graph #2 at influent BOD concentrations below 40 ppm, where reductions drop from 60% at 40 ppm to 40% at 20 ppm.

It was seen from Graph #1, that oxygen became limiting at loadings above 5 lb BOD/1000 cuft/day, and yet, the BOD reductions were highest at this high loading. It would appear then, that either additional aeration guns or a more efficient type of aerator would allow higher loadings to the pond and thus increase removal efficiencies.

There appears to have been a direct relationship between effluent suspended solids concentrations and algae densities. Thus, it would appear that the growth of algae should be prohibited when possible. Maintaining retention periods less than 2 days appears to be one solution. The covering of the pond with suspended terylene mats as has been attempted in South Africa (2) may be another solution.

BOD reductions also appear to be most reliable at a retention period of 1 to 2 days, seemingly because of the absence of large quantities of algae; however, in the absence of algae, reductions appeared to be higher at retention periods of 3 to 4 days. Thus, if algae densities could be suppressed mechanically or chemically, BOD reduction could be increased by increasing retention times, maintaining a high organic loading and an adequate dissolved oxygen content.

CONCLUSIONS

The following conclusions are based on the detailed analysis of 26 weeks of data and general analysis of some 35 weeks of sampling results. The limits set are subject to adaptation to the varying conditions which are necessarily found at different locations and installations. They are general in nature, however and may be used as guidelines in the design and operation of future effluent polishing installations.

The conclusions of the pilot plant study in respect to the aeration pond as aerated by an Aero-Hydraulics aeration system are as follows:

1) Limits of organic loadings applied to the aeration pond may be set at 0.9 lb BOD/1000 cuft/day and 5.0 lb BOD/1000 cuft/day.

2) Temperatures should not be allowed to drop below 5°C.

3) Retention periods should be between 1 and 2 days to achieve fairly constant BOD reductions and discourage large densities of algae.

4) Temperature changes between 6° and 20°C appear to exert little effect on treatment efficiency.

5) Some provision should be allowed for either preventing excessive settling in the aeration pond, or for sludge removal.

6) Dissolved oxygen levels should not be allowed to drop below 1.5 ppm at any time.

7) An effluent of between 4 and 8 ppm BOD would be maintained if influent BOD concentrations were not allowed to exceed 15 ppm.

8) The aeration pond should eliminate shock loads to the receiving stream and remove most of the settleable solids, thus eliminating drastic changes in quality of the stream and virtually eliminating the formation of sludge deposits in the stream.

Teritiary treatment is not a substitute for reliable secondary treatment. The first step must therefore be to eliminate the opportunity of any partially or poorly treated effluent from leaving the secondary plant.

An effluent with a BOD not exceeding 8 ppm will be maintained if:

1) An effluent of 15 ppm or less BOD can be maintained by the secondary sewage treatment plant,

2) An aeration pond of 1 to 2 days retention period, with minimum and maximum loadings compatable with nutrient and air supply, respectively.

3) An adequate oxygen supply to maintain a DO level of 1.5 ppm is provided.

4) Adequate mixing is provided to prevent excessive settling of sludge (or sludge removal facilities are provided).

PILOT PLANT UNIT

The conventional lagoon was constructed in 1964, with its operation and studies commencing in August of that year. It is an earth-dyke basin with side slopes of approximately 2.5:1, a depth of 8 ft. and surface area of 1 acre giving a total volume of 2.2 million gallons.

LAGOON TREATMENT

The lagoon, because of its depth, is facultative rather than aerobic with aerobic activity taking place in the upper layer and anaerobic in the lower. The depth of interface is dependent upon dissolved oxygen conditions as supplied through algae photosynthesis, surface mixing and in the influent.

As with the aeration pond, anaerobic activity is reduced during the winter, creating an added loading effect during the warm-up period in the spring.

This phenomenon occurred somewhat earlier than with the aeration pond, taking place in April and early May as temperature increased from 4 to 12^{o}C. Perhaps because of the reduction of SS in the aeration pond, its effect was not as prominent as with the aeration pond.

Since DO input is highly dependent upon environmental conditions the treatment in the lagoon is not as reliable as that of the aeration pond which receives supplemental oxygen.

INTERPRETATION OF RESULTS

Again, in order to reduce the accumulation of data to useable proportions, all determinations have been based on weekly averages of test results. The test period covered consists of 52 weeks of data collecting. Again because of incompleteness of data only 33 weeks have been used as a basis for this report.

Table 3 presents weekly averages of pertinent data.

RESULTS

A. Biochemical Oxygen Demand

The variables affecting BOD removal in the lagoon considered in this report are loading, influent concentrations, retention period, temperature and algae concentrations.

As can be seen from Graphs #7 and #8, no direct correlation between BOD% reduction and either retention time or loading could be established. However, effluent BOD was somewhat dependent upon both loading and influent BOD concentration.

With influent BOD concentrations below 15 ppm, the effluent ranged between 3.5 ppm and 7.5 ppm, while loadings below 21 lb BOD/acre/day produced an effluent varying between 4 and 6.5 ppm BOD. This corresponded to a BOD reduction varying between 40 and 80%

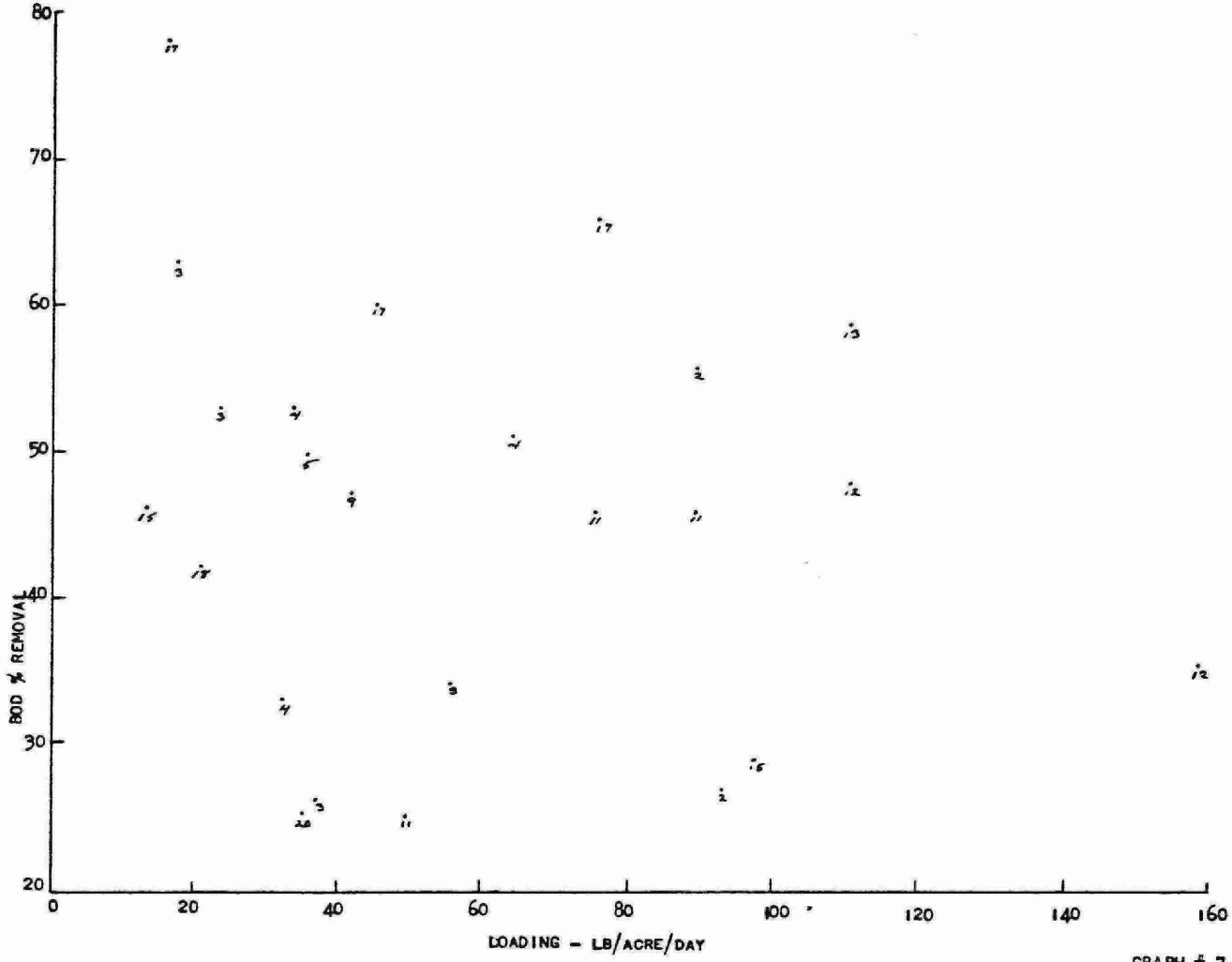
Effluent BOD concentrations appeared to be little effected by retention period except that the scatter was highest at retention periods below 8 days. See graphs #9, #10 and #11.

Week	Loading #(Acre) Day	DO (ppm)	Temp. (°C)	Ret.Time (Days)	Algae (ASU/ Nil)	Eff. BOD (ppm)	Filt BOD (ppm)	BOD Red %	Inf. BOD (ppm)
2	12.3	2.5	15	15.8	35,000	4.7	4.5	46	9
3	15.7	3.5	17	15.7	2,800	3.6	2.5	78	8
4	20.2	3.9	18	9.0	70	3.9	3.9	42	8
5	34.8	3.3	20	7.5	60	6.3	3.3	25	12
6	28.8	3.7	19	9.5	6,000	8.8	4.2	2	12
7	43.8	10.6	17	6.1	31,000	15.0	4.2	-	12
8	75.1	2.8	17	4.9	7,000	9.5	5.1	66	17
9	96.9	1.8	15	4.9	3,000	12.8	5.2	29	22
10	110	2.8	13	5.1	5,000	11.5	6.3	59	26
11	110	2.1	12	5.5	4,200	13.1	7.6	48	28
12	158	1.1	12	4.9	--	20.5	7.5	27	36
13	88.6	2.3	11	5.9	22,000	16.5	7.3	45	24
14	72.7	2.3	11	7.6	26,000	15.1	5.5	46	25
15	49.3	1.5	11	11.3	8,000	11.9	7.5	73	25
16	29.2	1.7	9	11.9	5,600	12.2	6.2	20	16
17	31.5	4.9	4	12.0	2,500	12.0	6.2	33	17
18	36.5	6.0	3	12.0	700	13.0	6.0	26	20
19	23.0	4.0	3	20.2	500	12.2	6.2	53	21
20	17.0	2.7	3	21.5	300	10.7	7.1	63	17
25	89.3	6.5	2	10.9	1,400	11.6	7.8	56	31
26	115	1.9	3	6.0	1,300	19.0	9.8	21	33
27	93	0.5	2	6.8	600	20.0	11.1	27	28
28	67	1.0	4	6.3	80	19.0	12.1	5	19
30	55	5.4	3	6.1	400	11.0	6.3	34	15
31	63	5.3	4	6.9	1,700	10.2	5.5	51	19
32	33	6.1	4	6.5	800	7.3	4.7	53	10
33	35	8.0	5	6.5	1,500	6.3	4.1	50	11
34	42	7.9	4	6.6	700	5.7	3.6	60	13
35	8	12.8	4	25.2	2,300	6.3	3.3	14	10
36	11	15.1	7	23.9	12,000	8.2	3.9	-20	12
37	17	21.2	9	22.2	23,000	10.8	2.5	10	17
38	12	21.4	7	22.9	38,000	15.0	3.5	-120	13
39	11	20.8	9	11.0	30,000	18.0	3.1	-52	13

Table 3 - Lagoon
- Brampton Pilot Plant
- Average Weekly Results - Aug., 1964 to May, 1965

Week	Infl. SS (ppm)	Effl. SS (ppm)	SS Red %
2	45	42	- 48
3	31	34	31
4	37	21	89
5	34	19	51
6	20	22	- 38
7	28	32	- 46
8	19	16	69
9	20	15	31
10	32	21	21
11	33	25	53
12	42	31	15
13	36	34	- 3
14	41	37	1
15	23	31	7
16	20	21	8
17	19	17	47
18	21	14	58
19	22	10	108
20	15	10	31
25	31	10	66
26	60	24	38
27	26	21	30
28	24	19	28
30	20	13	52
31	25	10	72
32	20	9	60
33	18	21	- 80
34	18	16	38
35	16	13	87
36	23	23	- 140
37	28	46	- 320
38	17	56	- 424
39	19	64	- 157

Table 3 Continued



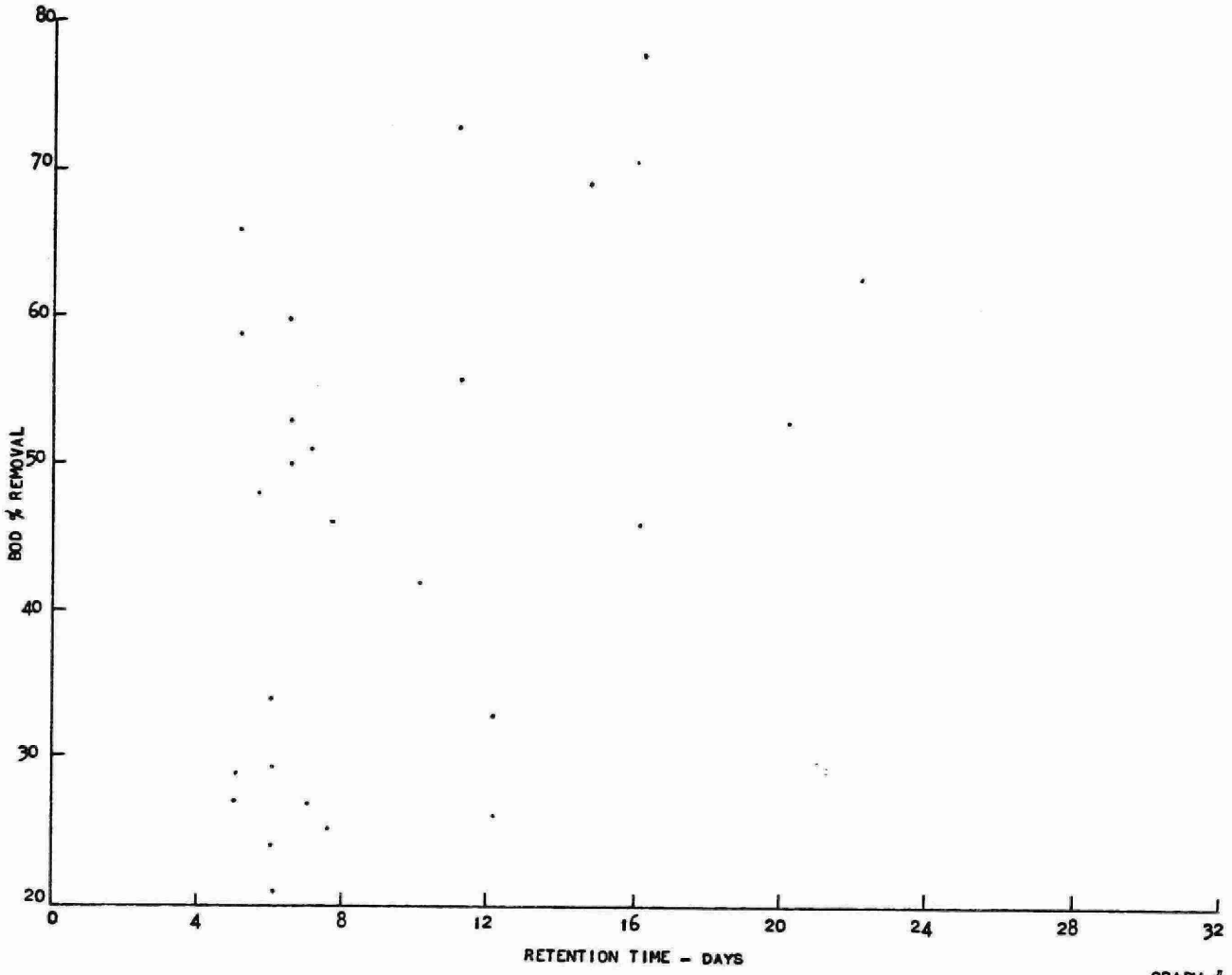
GRAPH # 7 APRIL 1966

BOD % REDUCTION VS LOADING

AVERAGE WEEKLY RESULTS - AUG./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (C) GIVEN FOR EACH POINT

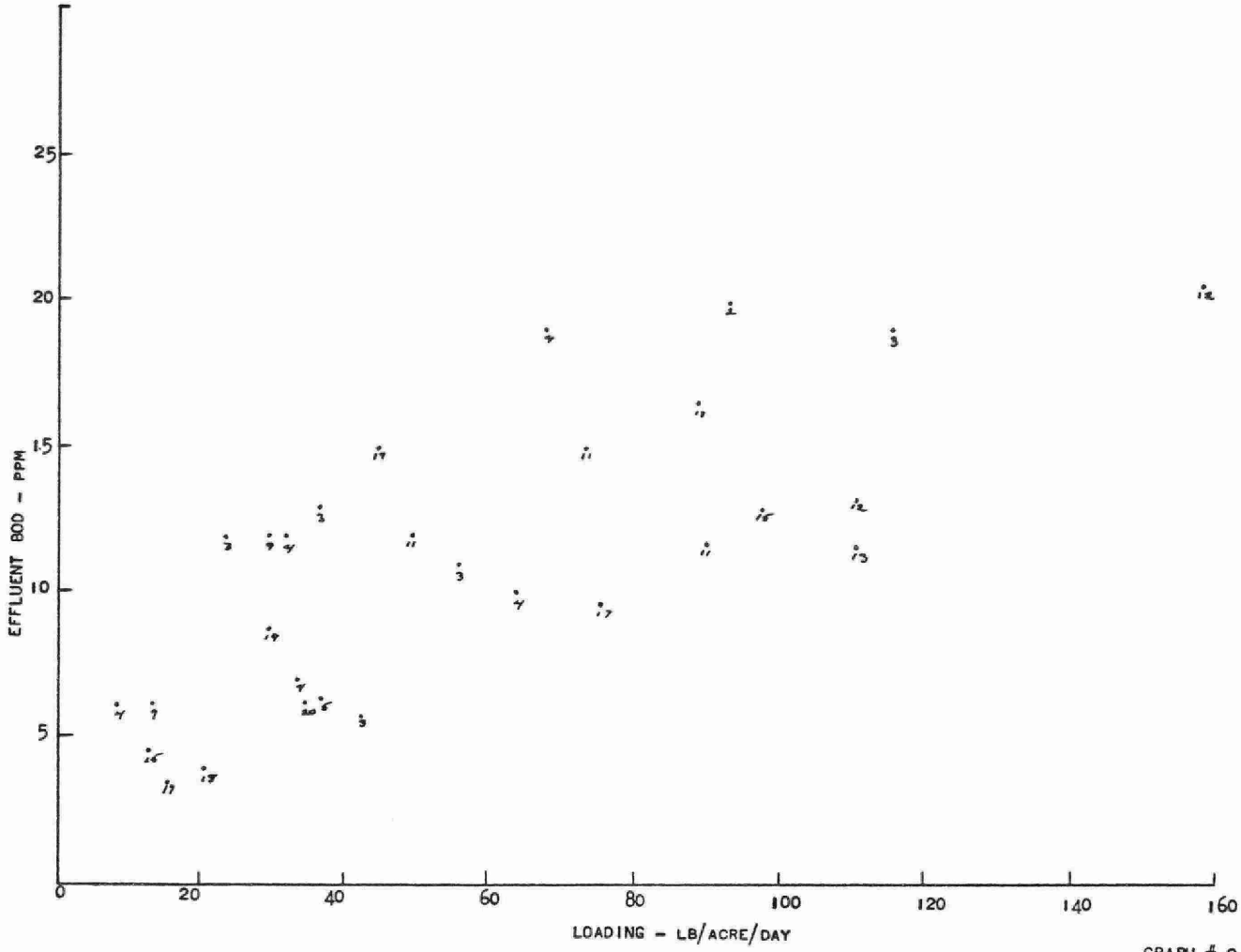


GRAPH # 8 APRIL 1966

BOD % REMOVAL VS RETENTION TIME

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT



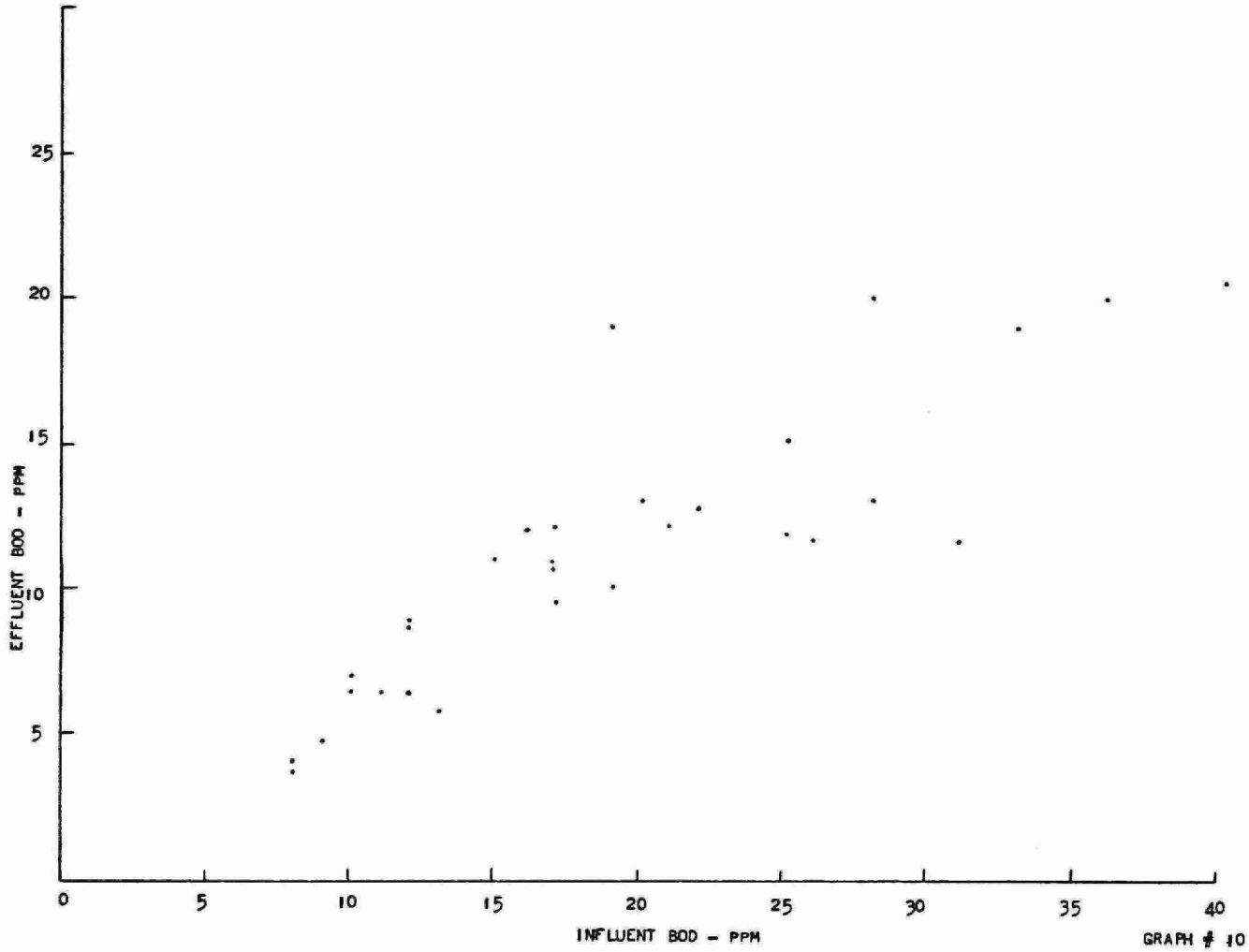
GRAPH # 9 APRIL 1966

EFFLUENT BOD VS LOADING

AVERAGE WEEKLY RESULTS - AUG./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (C) GIVEN FOR EACH POINT

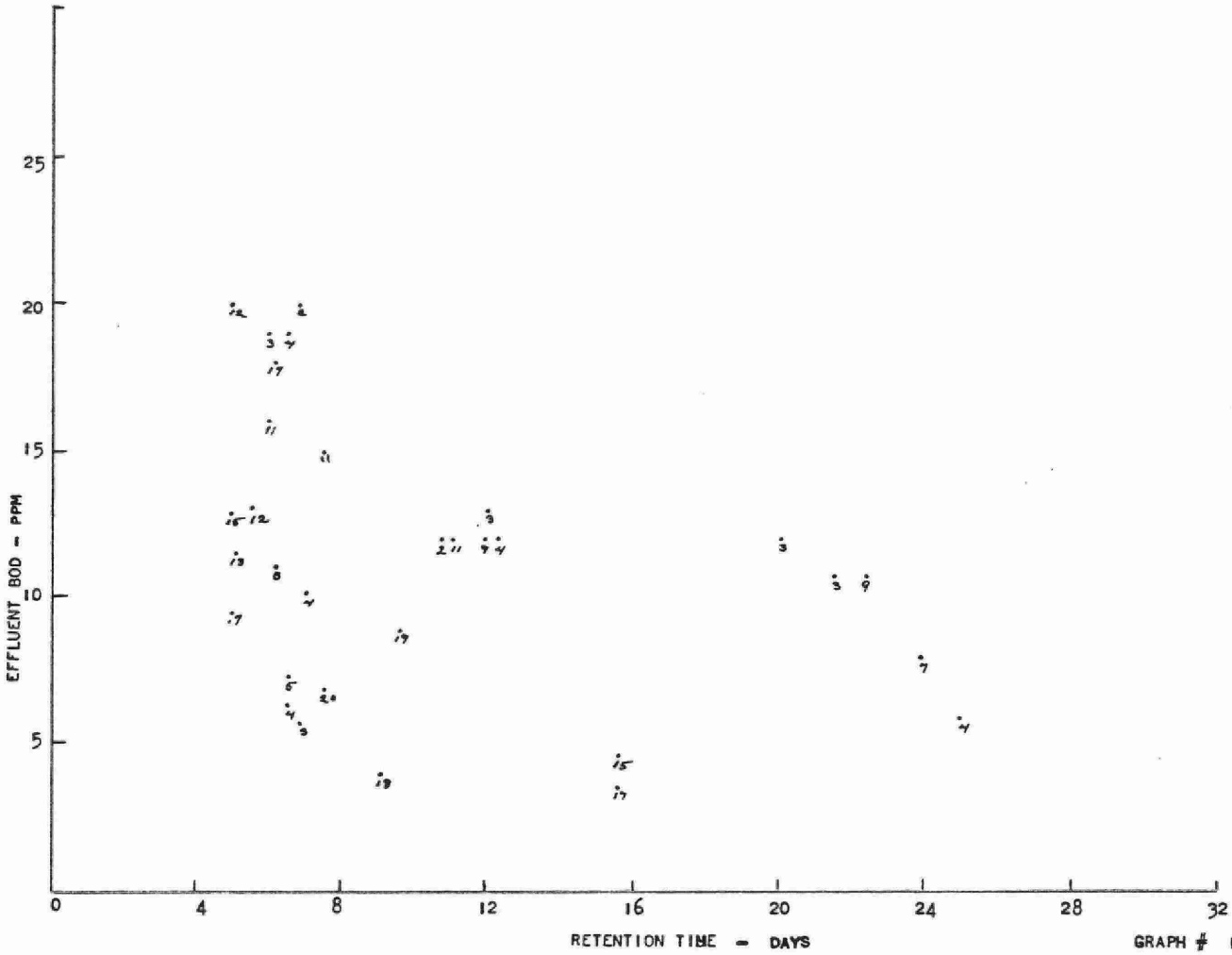


GRAPH # 10 APRIL 1966

EFFLUENT BOD VS INFLUENT BOD

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT



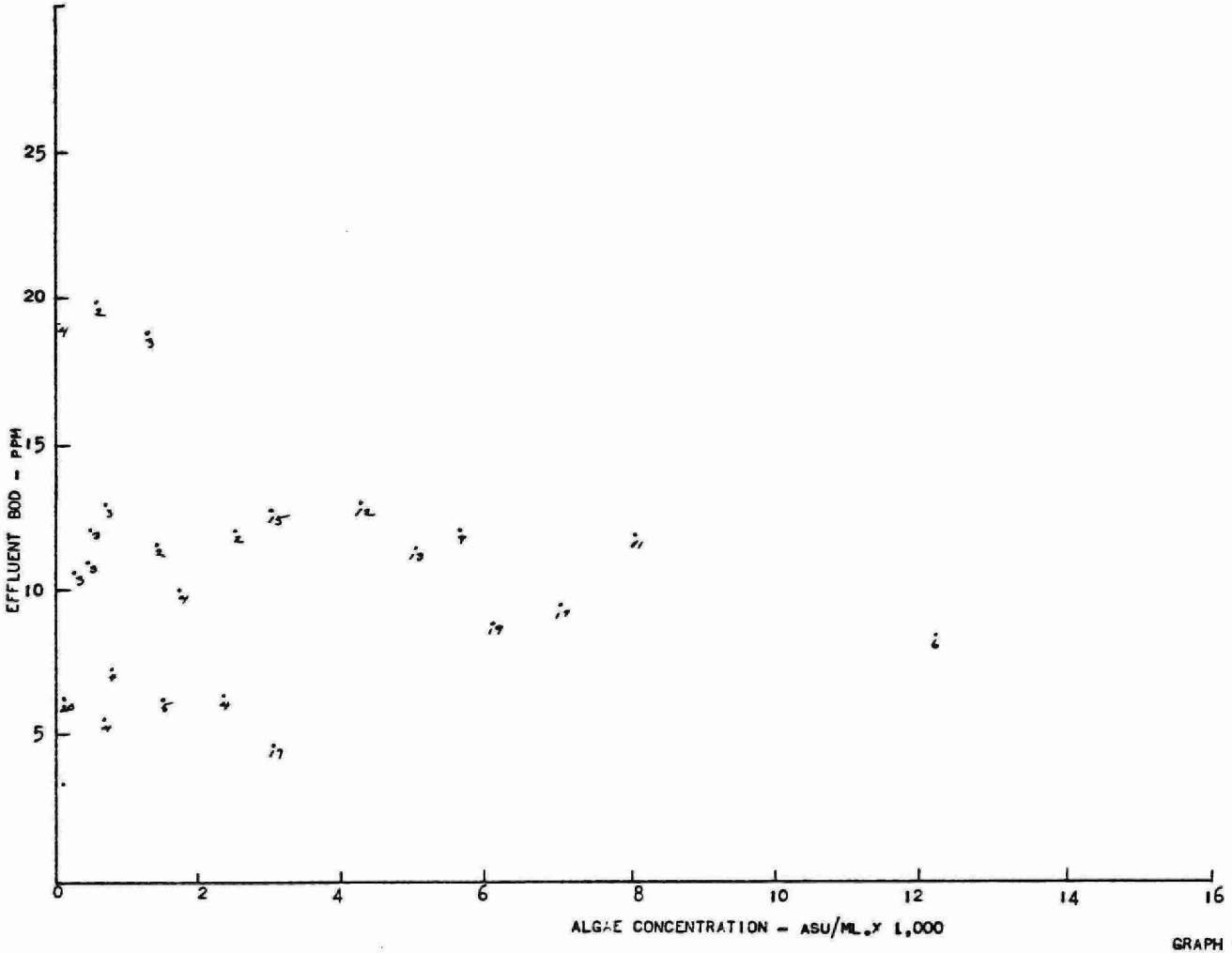
GRAPH # 11 APRIL 1966

EFFLUENT BOD VS RETENTION TIME

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (C) GIVEN FOR EACH POINT



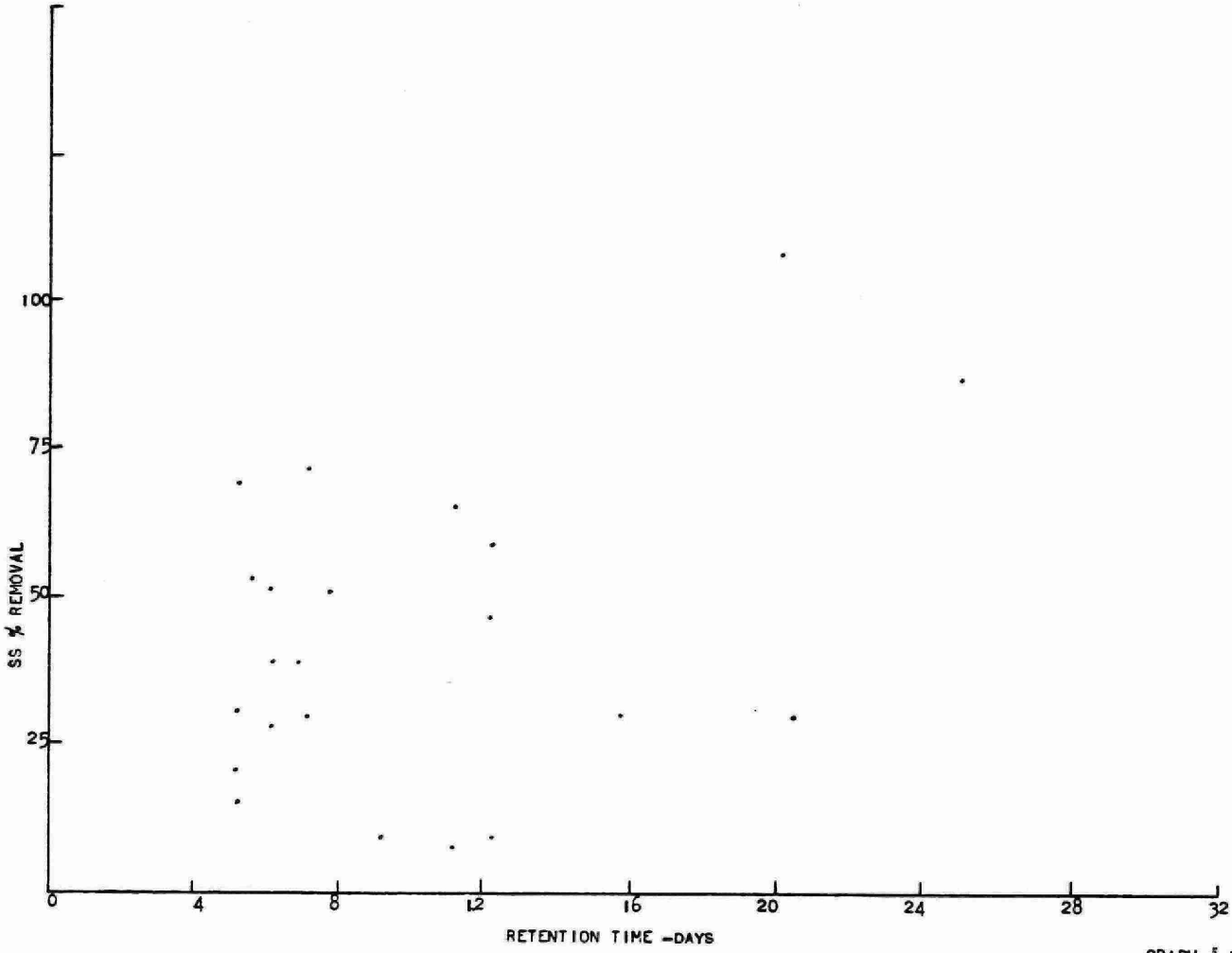
GRAPH # 12 APRIL 1966

EFFLUENT BOD VS ALGAE CONCENTRATION

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT

AVG. TEMP. (C) GIVEN FOR EACH POINT

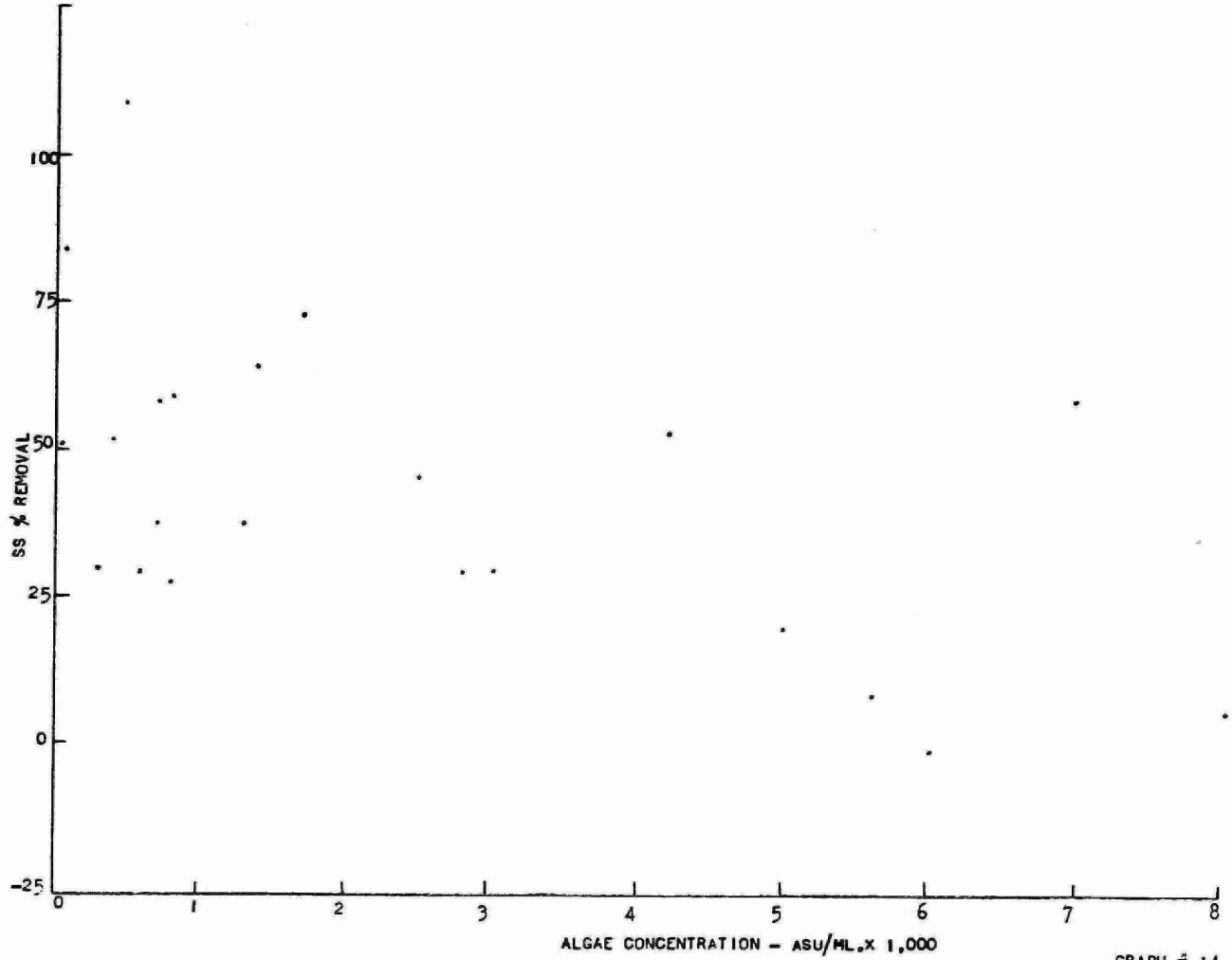


GRAPH # 13 APRIL 1966

SS % REMOVAL VS RETENTION TIME

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT

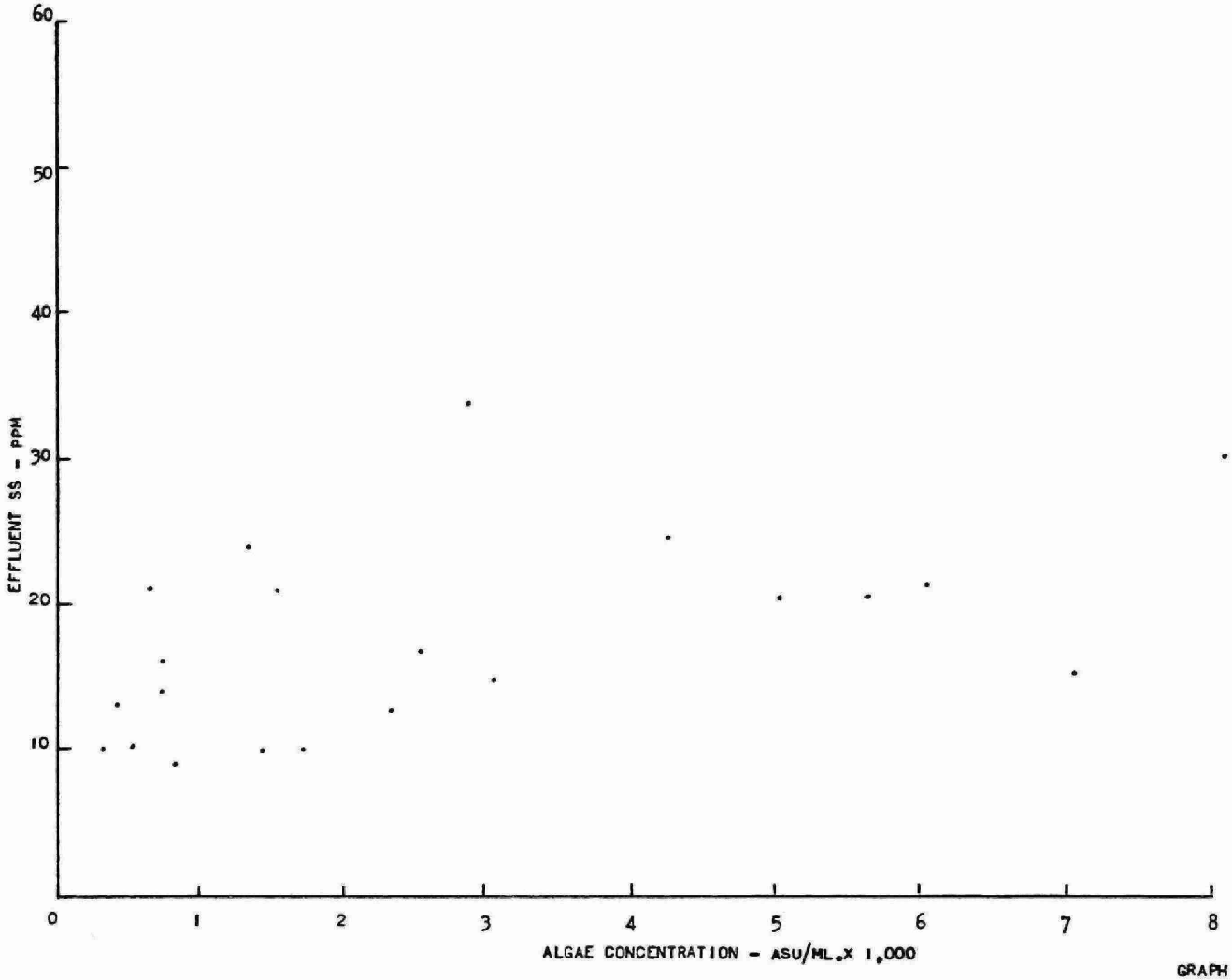


GRAPH # 14 APRIL 1966

SS % REMOVAL VS ALGAE CONCENTRATION

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT



GRAPH # 15 APRIL 1966

EFFLUENT SS VS ALGAE CONCENTRATION

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

BRAMPTON PILOT PLANT

Temperatures have been indicated with the points on graphs #7, #9, #11 and #12. From graph #12, it would appear that low temperatures (below 10°C) generally prohibited large densities of algae, however, exceptions did occur. Low temperatures except perhaps those below 3°C did not have any appreciable effect on BOD reductions.

B. Suspended Solids

Plots of SS % removal against retention time and algae concentrations are presented in Graphs #13 and #14. As can be seen, no direct correlation could be found in either case, except that at algae concentrations below 4,000 to 5,000 Areal Standard Units per millilitre (ASU/ml) the SS removal appeared to be more consistently higher, being between 25 and 75%. Thus, it would appear that algal cells are the main contributions to the SS content of the lagoon effluent, especially at very high algae concentrations. See Graph #15. Variations in temperature and influent quality were also contributing factors, but to a lesser extent.

The question of the actual effect of algal cells on the quality of the receiving water again arises. Excessive concentrations should be avoided if possible.

DISCUSSION

The lagoon appeared to be less reliable as an effluent polishing facility than the aeration pond. The lagoon is considerably more sensitive to environmental conditions and treatment is therefore much more difficult to predict and define.

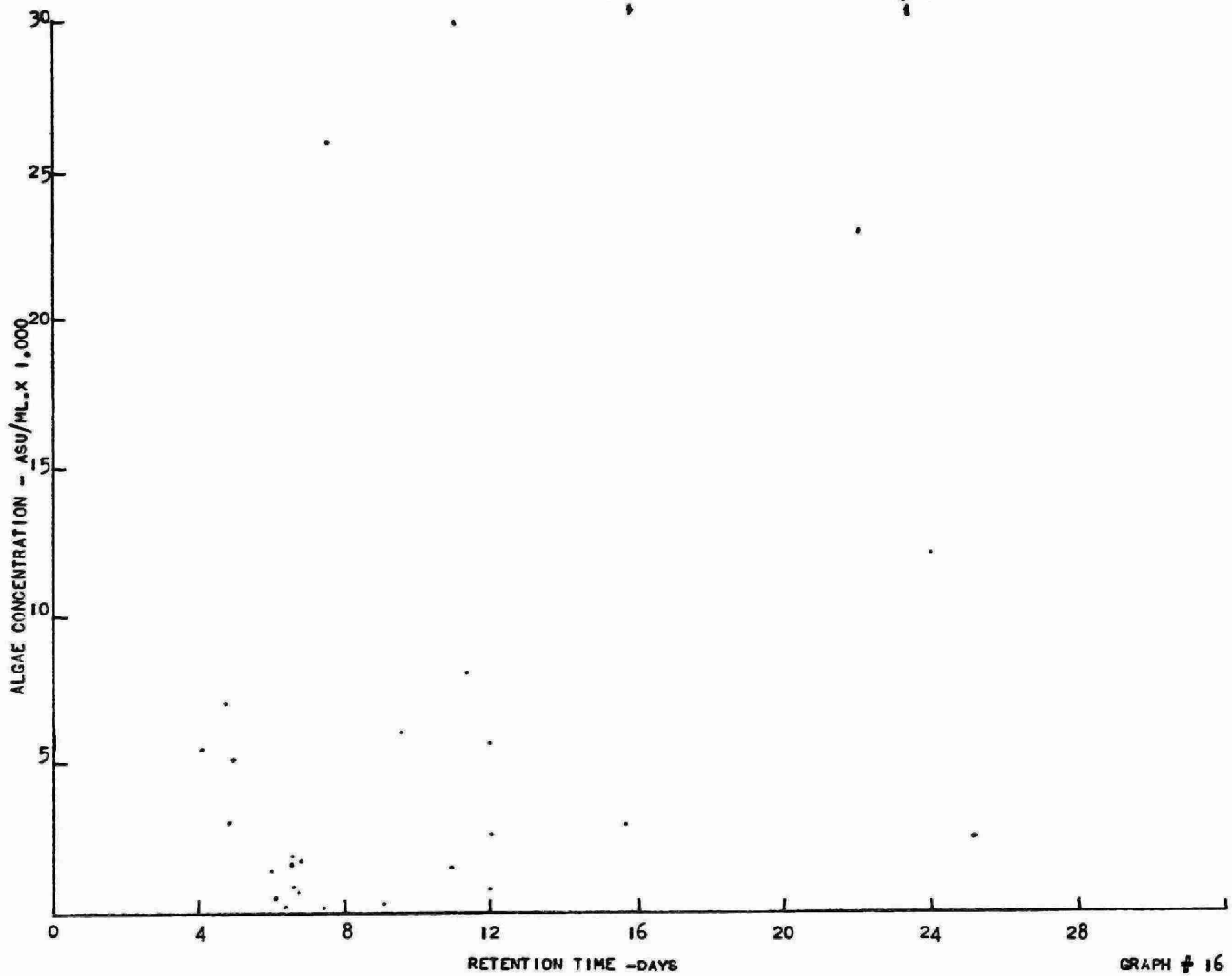
Algae is necessary as an oxygen supply to the aerobic organisms in the lagoon as lagoon treatment is largely dependent upon an adequate supply of oxygen. Dissolved oxygen concentrations reached a minimum in January of less than 1.0 ppm in the effluent of the lagoon.

Algae concentrations were also low at that time due to ice cover on the lagoon. When algae concentrations were at their highest (April) the lagoon effluent was greatly over-saturated with oxygen. It would appear then, that algae concentrations less than 1,000 to 2,000 ASU/ml were inadequate to provide sufficient oxygen, while concentrations above 10 to 12,000 ASU/ml generally produced an excess of oxygen. Dissolved oxygen concentrations in the lagoon effluent should never drop below 4 ppm because of the effect on the receiving water.

Values of filtered BOD in Table 3 indicate that approximately 50% of the effluent BOD was due to algal cells.

Graph #16 indicates that at retention periods of less than 8 days algae concentrations seldom exceeded 7,000 ASU/ml. However, the scatter of BOD removal efficiencies was greatest at retention periods below 8 days. Thus, some method to reduce the high algae concentrations, other than decreasing retention time would greatly enhance the treatment process.

A satisfactory effluent would be produced by the lagoon if the retention period is no less than 8 days, the loading no greater than 20 lb BOD/acre/day and the influent BOD concentration no greater than 15 ppm and if the algae concentration was not allowed to exceed 10,000 ASU/ml.



GRAPH # 16 APRIL 1966

ALGAE CONCENTRATION VS RETENTION TIME

AVERAGE WEEKLY RESULTS -AUG./64-MAY/65

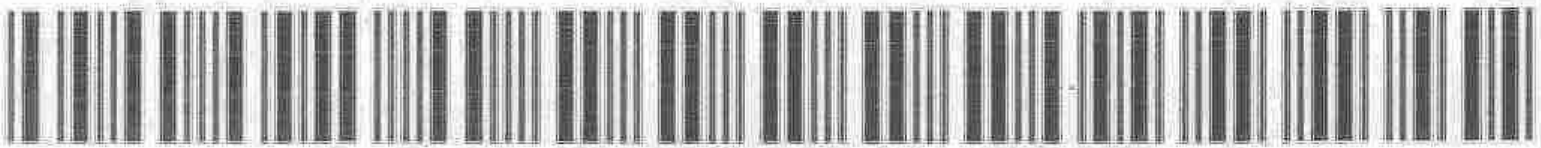
BRAMPTON PILOT PLANT

REFERENCES

1) Bryon, J.G. "System design and oxygen transfer", polution control manual and directory, CMW, 1965-66.

2) Van Eck, H., "Theory of Stabilization Pond and its Implication on their Design and Operation", C.S.I.R. Reprint RW, No.132, 1960.

3) O'Connor, D.J., Lecture Notes from Stream and Estuarine Analysis Course at Manhattan College, June 6-10, 1966.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